Giant steps for the science of stroke rehabilitation

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All patients who survive a stroke show some degree of spontaneous recovery over the weeks and months that follow; rehabilitation helps drive and shape this recovery. In countries where it is available, rehabilitation is provided by a raft of individuals, often over an extended period of time, and generally begins early. While individual patient goals may vary, rehabilitation is broadly oriented toward maximizing body functions and activities in order to help patients participate more fully in life. For the millions of people who experience a disabling stroke each year, and for their families, stroke rehabilitation offers hope.

Recent years have seen giant steps in the science of stroke rehabilitation (1). Experimental stroke animal research has provided a window into the cellular and molecular events underlying stroke rehabilitation and recovery. Advances in neuroimaging and neurophysiological methods have allowed us to go beyond bedside observations, providing insights into the brain events underlying behavioral improvement. Taking a neural systems approach has helped our understanding of both brain structure and function, and the evolution of brain states in the days and weeks after stroke. This increased understanding has fostered clinical trials, testing the utility of pharmacological, cell-based, device-based, activity-based, and other interventions to promote brain repair after stroke and so maximize the effects of stroke rehabilitation (2,3); neuroimaging techniques are now being used to help stratify enrollees (4).

With these advances come the realization that many questions remain unanswered, and that more research is needed to help our patients derive maximum gains from stroke rehabilitation. While we know that stroke rehabilitation delivered in a stroke unit is a highly effective model of care that reduces death and dependency (5), less well understood are the specific (or combined) interventions and care practices that contribute most to improved outcome. Important in the context of the current compendium is that intensive, task-specific training can effectively reduce disability, across a number of impairments, and that alternative models to classic inpatient rehabilitation can also improve outcomes (6) and are important to explore. However, in many cases, it remains unclear how effective treatments work. How are they best implemented? For whom do they work best? And when should such treatments start and end? Such questions are the focus of this special rehabilitation edition.

In the first review, Marion Walker and an international field of experts describe approaches to the translation of rehabilitation evidence into practice, sometimes referred to as T3 translational science. This can be challenging in any field and may be particularly so in rehabilitation where, in many countries, external drivers to support uptake of effective interventions or discontinuation of ineffective interventions such as payers or policy makers are missing or are not working collaboratively with clinicians. Developing, testing, and sharing effective models of translation that bring all of the key stakeholders together should improve clinical uptake.

International rehabilitation networks have only recently coalesced. The Virtual International Stroke Trials Archive (VISTA), which includes VISTA-Rehab, is one example, where rehabilitation trialists contribute their data. Myzoon Ali and colleagues

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explore this database and highlight an area of urgent need in rehabilitation: a core set of outcome measures, including biomarkers, for both clinical trials and the clinical practice of stroke rehabilitation. These points echo recommendations from the recent Stroke Synergium paper 'Stroke: Working Towards a Prioritized World Agenda' (7).

Identifying which patients are appropriate for stroke rehabilitation is an issue of great medical and economic significance that no doubt will extend to the emerging field of brain repair therapeutics (8). While some stroke rehabilitation interventions, such as strength training, are likely suitable for nearly all patients, other therapies are likely of benefit to only a specific subpopulation. Gert Kwakkel and Boudewijn Kollen examine a critical component of this issue, the accuracy of predicting recovery after stroke. One key message is that large, prospective, long-term studies that inform accurate outcome prediction are lacking but needed. While clinical assessment underpins many prediction models, there is evidence to suggest that measurement of brain injury and brain function can significantly contribute to prediction of outcome. Cathy Stinear and Nick Ward explore these points in their review, which also emphasizes the need for neuroimaging studies to be undertaken at key times when rehabilitation decisions are made. One day, neuroimaging may enable design of rehabilitation and brain repair therapy for an individual patient based on his/her capacity for specific forms of brain plasticity.

The frontal lobe is the largest lobe in the human brain and its functions distinguish us from the other species, with the vast majority of frontal lobe activity related to cognitive function. Rehabilitation for patients with cognitive impairment after stroke is a significant challenge, as highlighted by Toby Cumming *et al.* in their review. They provide a framework for understanding how cognitive dysfunction after stroke affects overall patient function, and outline avenues for future research for cognitive-based therapies.

The current special rehabilitation edition, in addition to the aforementioned five reviews, also includes three editorials that consider critical issues in stroke rehabilitation. Of central interest is the issue of when stroke rehabilitation should begin and when it should end, a topic examined in separate pieces by Julie Bernhardt *et al.* and by Nicol Korner-Bitenskey. These authors highlight the need to understand the optimal window of opportunity for recovery. Shanthi Medis from the World Health Organization reminds us that stroke is worldwide and its burden is growing, and that developing countries have limited infrastructure to address the need for stroke rehabilitation services. International trial collaborations are growing, and rehabilitation-based trials of simple interventions are now being tested in developing countries; for example, a trial of family-led stroke rehabilitation in India (ATTEND) was recently funded by the Australian National Health and Medical Research Council. These exciting developments showcase the commitment of the rehabilitation research community to tackling the global burden of stroke disability.

Finding new models for delivery of effective stroke rehabilitation therapies beyond the hospital setting is also part of our challenge. The current special rehabilitation edition is fortunate to include two trial protocols that address this issue, those by Linder *et al.* and by McCluskey *et al.*

At the recent World Stroke Conference in Brazil, the 11-item 'Post Stroke Checklist' was launched. The checklist includes questions about eight common poststroke problems, including mobility, incontinence, language, cognition, and mood (9). The World Stroke Organization will work toward the global uptake of this Checklist to facilitate regular follow-up of people affected by stroke. The Checklist is expected to help identify ongoing problems that are experienced by stroke survivors. The challenge for the stroke community is to find effective interventions that prevent or reduce these problems or help survivors manage them in the long term. In either case, stroke rehabilitation will be a core component of the treatment arsenal.

Together, the articles in the current special rehabilitation edition highlight some of the exciting advances in the science of stroke rehabilitation, and outline important next steps in this rapidly growing field. The authors are to be congratulated for lighting the way for the next great steps toward improving the recovery of people affected by stroke.

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